U.S. Antarctic Program, 1995–1996

During the 1995–1996 austral summer field season, 631 scientists and other specialists conducted 133 research projects in Antarctica. Supported by the National Science Foundation (NSF), these individuals worked at McMurdo Station on Ross Island; at remote field camps in the McMurdo Dry Valleys, Transantarctic Mountains, or West Antarctica; at Amundsen–Scott South Pole Station; aboard the icebreaking research ship *Nathaniel B. Palmer*; at Palmer Station on Anvers Island; and in southern ocean waters near the Antarctic Peninsula. Studies at the remote field camps included investigations of the continent's geologic and glacial history, the dynamic behavior of the west antarctic ice sheet, and the characteristics and ecology of the sparse terrestrial life inhabiting the dry valley region. About 4 percent of these projects were conducted in conjunction with other national antarctic programs or supported aboard commercial tour ships.

The projects described in this issue of the *Antarctic Journal* represent only part of the science effort supported by NSF through the U.S. Antarctic Program. Besides the science teams working in Antarctica, researchers in the United States continued to analyze data acquired during previous austral summers. This volume of the *Antarctic Journal*, which is comprised of papers prepared by program participants, reflects the breadth and complexity of the U.S. program. The articles describe field research, data analysis, and related activities in Antarctica and the United States. For colleagues within their specific disciplines, researchers have published their detailed results and findings in peer-reviewed scientific journals. In contrast, the *Antarctic Journal*, which is not peer-reviewed, is intended to provide an overview of recent investigations and to make initial reports available to investigators across all scientific disciplines as well as to the public. The assistance of all participants who contributed material to this issue is gratefully acknowledged.

Season research highlights—1995–1996

- *AMANDA.* Over the past two decades, technology has made it possible to build a "telescope" that can image the sky using high-energy neutrinos, one of the most common subatomic particles in nature. Although they interact only weakly with ordinary matter, making them very difficult to detect, neutrinos are so penetrating that they help astronomers to "see" inside of celestial objects (such as the cores of galaxies) that are shrouded in dust, stars, and gasses that obscure viewing at any wavelength of electromagnetic radiation. To detect a neutrino, unfortunately, requires an enormous detector with a very good filter. At the geographic South Pole, researchers have been testing the use of ice as a detector. The Antarctic Muon and Neutrino Detector Array (AMANDA) uses the glacial ice of the ice sheet at South Pole as the world's largest particle detector. During the 1995–1996 austral summer, researchers successfully installed 86 more optical modules on four strings between 1,500 and 2,300 meters deep in the ice. Including the four strings previously installed between 800 and 1,000 meters, this brought the total number of optical modules to 166. Although the researchers have found that the ice is much clearer than anticipated from laboratory measurements, at the shallower depths (less than 1,500 meters), residual air bubbles cause an excessive amount of scattering, making that part of the ice sheet less useful. Consequently, future development is expected to be done in deep ice.

- *AST/RO.* The Antarctic Submillimeter Telescope and Remote Observatory (AST/RO), one of several projects operated by the Center for Astrophysical Research in Antarctica (CARA), completed its first winter of operation. The project uses a 1.7-meter-diameter telescope to conduct surveys of atomic and molecular line emission from interstellar gas in the galactic plane, the galactic center, and the Magellanic Clouds. During its first winter of operation, it produced more than 100,000 spectra of atomic carbon in cool molecular clouds in the Milky Way as well as spectra of several trace gases in the Earth's atmosphere. The mapping of carbon provides information on star-forming regions not available at other wavelengths. South Pole is the only site on Earth that can reliably take spectra at this wavelength.

- *Southern ocean carbon cycling research.* Use of new technologies and fortuitous timing during the southern ocean spring bloom revealed new pathways of carbon cycling in the Ross Sea. Oceanographers used a remote-controlled underwater TV camera and sediment traps to probe the fate of carbon fixed during highly productive phytoplankton blooms that occur every spring as ice retreats around the Antarctica. Immediately after the bloom when waters were highly transparent, TV reconnaissance revealed that a surprisingly large fraction of the bloom had settled to the bottom at 200 meters depth. Shrimplike krill were observed there in high concentrations where they fed on the bloom debris lying on the bottom. Krill, a key component of the southern oceans ecosystem, are a link between microscopic plants (phytoplankton) and higher trophic levels. Without the use of the small, submarine-mounted TV camera, this pathway of photosynthetic carbon would not have been so easily discovered.

- *Icefish antifreeze glycopeptides.* Because of the high salt content, seawater surrounding the antarctic continent freezes about 2 degrees below that of freshwater. Fish swimming in these waters theoretically should freeze; however, their blood and tis-

sues contain glycopeptides that prevent freezing. These compounds act by attaching to small ice crystals and preventing them from joining together to form larger crystals. Currently, researchers are attempting to clone these glycopeptides so that these compounds potentially could be used to prevent ice-crystal formation in frozen human tissue and in living plants or as nontoxic deicing agents for airplanes and roads.

- *Vostok ice-core drilling project.* The United States, Russia, and France continued to collaborate on ice-core drilling at Vostok Station in East Antarctica. Recent drilling efforts have produced the oldest ice core ever sampled. The deepest ice (3,350 meters) is thought to extend through several glacial/interglacial cycles and could be as much as 450,000 years old. The Vostok ice core, which has provided a wealth of information about past climate and environmental changes in Antarctica, has allowed scientists working on the GISP2 ice core from Greenland to make climate correlations between the Northern and Southern Hemispheres. The Vostok core has also provided one of the most detailed records to date of paleoatmospheric concentration of methane and carbon dioxide and has helped scientists to improve their understanding of how these greenhouse gases have responded to (or were a cause of) climate change in the past.

- *Invertebrate paleontology.* The world's oldest crayfish (freshwater lobster) body fossil, a claw, was discovered in the Shackleton Glacier region in 1995–1996, along with numerous trace fossils of crayfish. The oldest body fossil by 65 million years, it pushes the evolutionary developments back in Earth's history by a significant amount of time.

- *Seafloor bathymetry.* The Earth is dominated by ocean basins, but despite their dominance, the ocean floor is largely unexplored and unmapped. Without detailed seafloor maps, the ability of scientists to address such basic questions as "What happens when continents break apart?" or "How does continental drift work?" is limited. Recent advances in technology that uses sound waves to measure distance in water have provided new remote-sensing capabilities and the potential for creating detailed seafloor maps. Using one of these systems (Seabeam 2112™), marine geologists working the Bransfield Straits aboard the *Nathaniel B. Palmer* found lineated pillow piles (volcanic rock formed by underwater eruptions) interspersed with one nearly perfect submarine volcano and one apparently dissected submarine volcano. The better preserved volcano is about 3 nautical miles across at its rim, stands 900 meters above the bottom, but is still 600 meters below the ocean surface. Geologists Lawrence Lawver of the University of Texas–Austin and Gary Klinkhammer of Oregon State University observed that "lineated pillow piles of these lengths are completely unknown in the world's oceans. Perhaps as more areas are surveyed they may turn out to be more common, but so far the central Bransfield Basin is unique." They also found two hydrothermal vent fields whose sizes rival the largest geothermal field on the Mid-Atlantic Ridges and a compressional ridge equal in size to the San Bernadino Mountains of southern California.

- *Sea-ice dynamics.* Two midwinter cruises of the *Nathaniel B. Palmer* to the Pacific sector of the southern oceans focused on the freezing of ice, the effect of snow on the growth of the ice pack, and the structure of individual ice crystals. The resulting data are the best currently available on antarctic sea ice and snow structure. In March and April, heading into the southern winter, antarctic sea ice expands at a rate of 57.2 square kilometers per minute until it covers an area twice that of the United States. In summer, it melts more slowly but by the following February has retreated to a narrow fringe surrounding the continent. With the relatively warm water isolated from the atmosphere, surface temperatures fall to values 15–30˚F (8–15˚C) lower than they would be over the open ocean. The northward extent of the winter sea ice also has significant climatic consequences. The temperature contrast between the ice and open ocean helps to drive the intensity of cyclones that circle the continent and to fix the preferred latitude of Southern Hemisphere storm tracks. The year-to-year variation in the extent of sea ice is determined by oceanic processes that can bring stored heat to the surface and prevent ice from forming and by atmospheric processes that can alternately drive the ice northward or southward. Using satellites to observe and track sea-ice dynamics, scientists can use variations in the sea-ice cover as an indicator of global climatic change.

- *Antarctic automatic weather station network.* Approximately 50 automatic weather stations continued to produce reliable and accurate data throughout the 1995–1996 season. These rugged instruments, developed for the U.S. Antarctic Program, have performed well in some of the most rigorous climatic conditions on Earth. Measurements of surface temperature, pressure, wind, and humidity are uplinked to polar orbiting satellites and delivered electronically for weather forecasting and research purposes to users in Antarctica and in the United States. The automatic weather stations are the primary direct data source for much of the antarctic continent and represent a valuable data set for validating satellite imagery.

Policy highlights

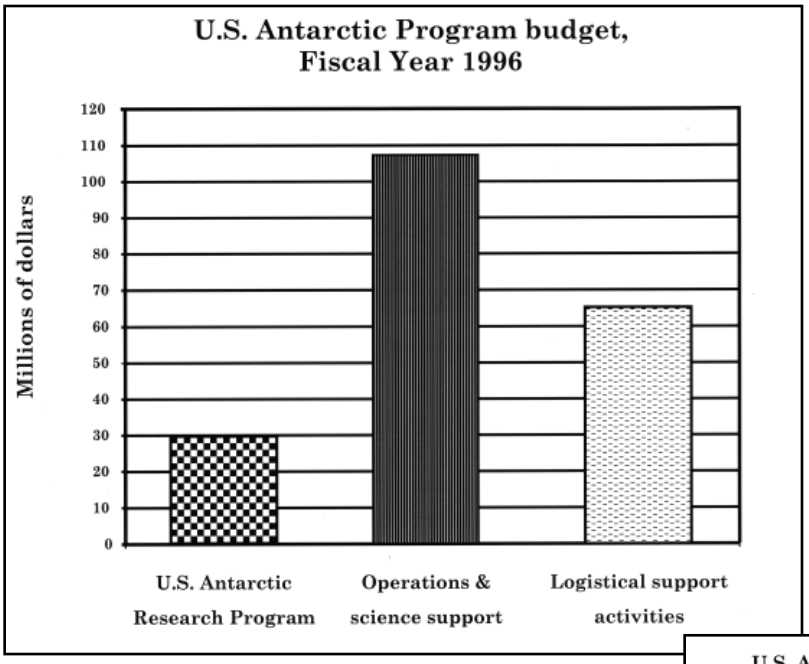
In September 1995, the Senate Appropriations Committee on Veterans Administration, Housing, and Urban Development, and Independent Agencies requested that the National Science and Technology Council (NSTC) review U.S. antarctic policy, because the committee was aware that the National Science Foundation was considering redevelop-

ment of Amundsen–Scott South Pole Station. The NSTC was asked to examine U.S. antarctic policy "in the context of the value of the science performed in Antarctica and other U.S. interests" and, specifically, to "address the affordability of continued U.S. presence in Antarctica in light of the severe budget environment and examine options for reducing annual logistical and operational budget needs." (*United States Antarctic Program*, 1996, Committee on Fundamental Science, National Science and Technology Council).

The NSTC's Committee on Fundamental Science completed its review and delivered its report to Congress in April 1996. Emphasizing that the United States should maintain an active and influential presence in Antarctica, the Committee concluded that

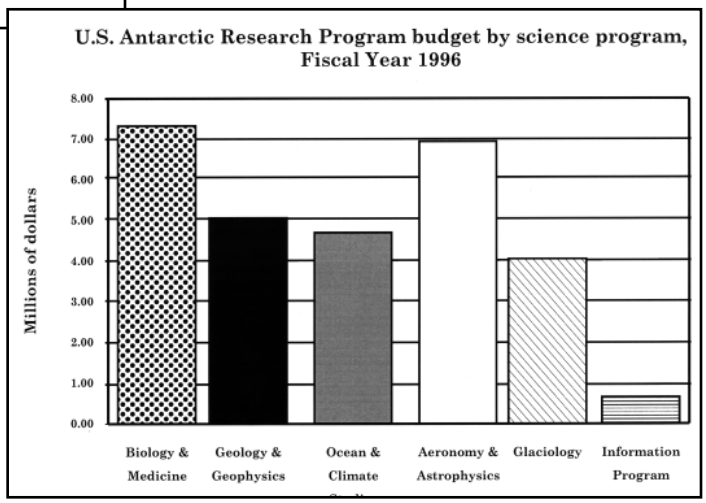
> USAP is cost effective in advancing American scientific and geopolitical objectives, and, from a science perspective at the current level of investment, [the NSTC supports] the continuation of three stations with year round presence. (*United States Antarctic Program*, 1996, Committee on Fundamental Science, National Science and Technology Council)

It also found that the science conducted in Antarctica is of high quality and of interest to a broad scientific community and that often the results of these investigations imply consequences for human activity beyond those usually associated with basic research. To explore options for sustaining the high level of U.S. antarctic science activity under realistically constrained funding levels, the NSTC recommended that NSF convene an external panel. The panel, which was comprised of 11 members, began its review in October 1996 and concluded in April 1997.



For Fiscal Year 1996, the National Science Foundation received $202.03 million for the U.S. Antarctic Program. These funds fall into three major categories:

- U.S. Antarctic Research Program .... $29.45 million
- Operations and science support ..... $107.35 million
- Logistical support activities ..... $65.22 million
  (Funds provided for Department of Defense support)



Funds ($29.45 million) provided for the U.S. Antarctic Research Program were awarded for research and related grants in the following categories:

- Biology and medicine..... $7.33 million
- Geology and geophysics..... $5.07 million
- Ocean and climate studies..... $4.71 million
- Aeronomy and astrophysics..... $6.94 million
- Glaciology..... $4.06 million
- Information program..... $0.66 million